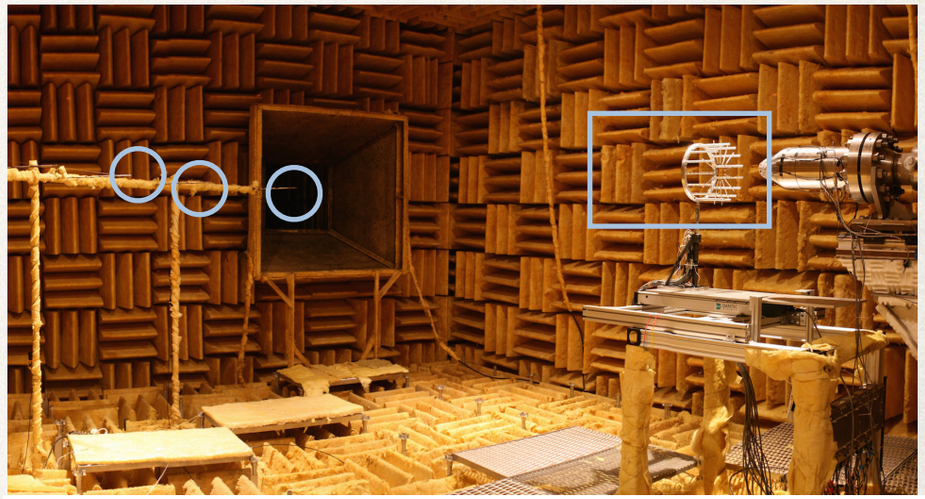
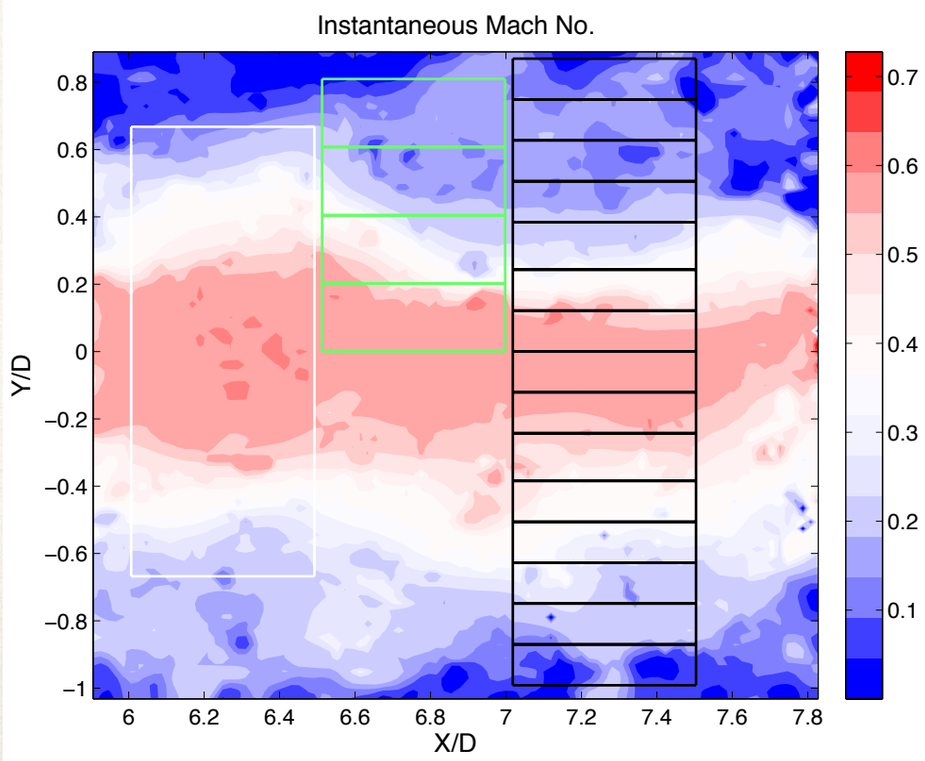
Subsonic Round Jet

Experiment Data

- Ma = 0.6 (Low et al, 2013)
- Far-field: microphone signals sampled at 40.96kHz
- Near-field: 10 kHz TRPIV (0.8623 seconds)
  - Diagnostic signals
  (spatial filtered from velocity fields)





Subsonic Round Jet

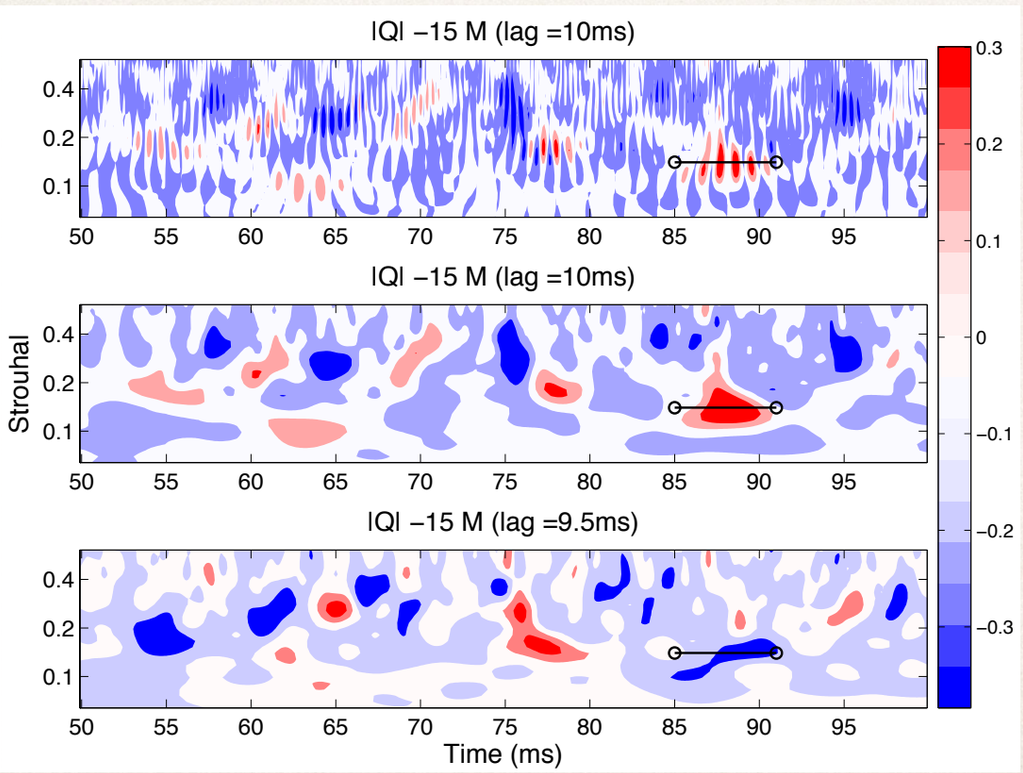
Events Related to Noise Production

Algorithm of Event Extraction

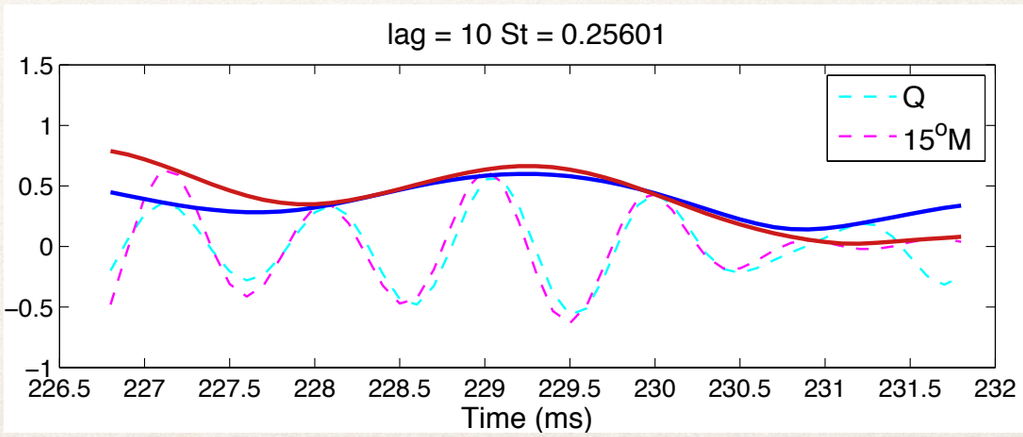
— Correlation, Continuous Wavelet, Pattern Recognition

- Main NF-FF correlation contributors: local extrema of the envelope

$$X(\tau, f, t) = \mathcal{R}(\tilde{p}(t, f) \cdot \tilde{q}^*(t + \tau, f))$$



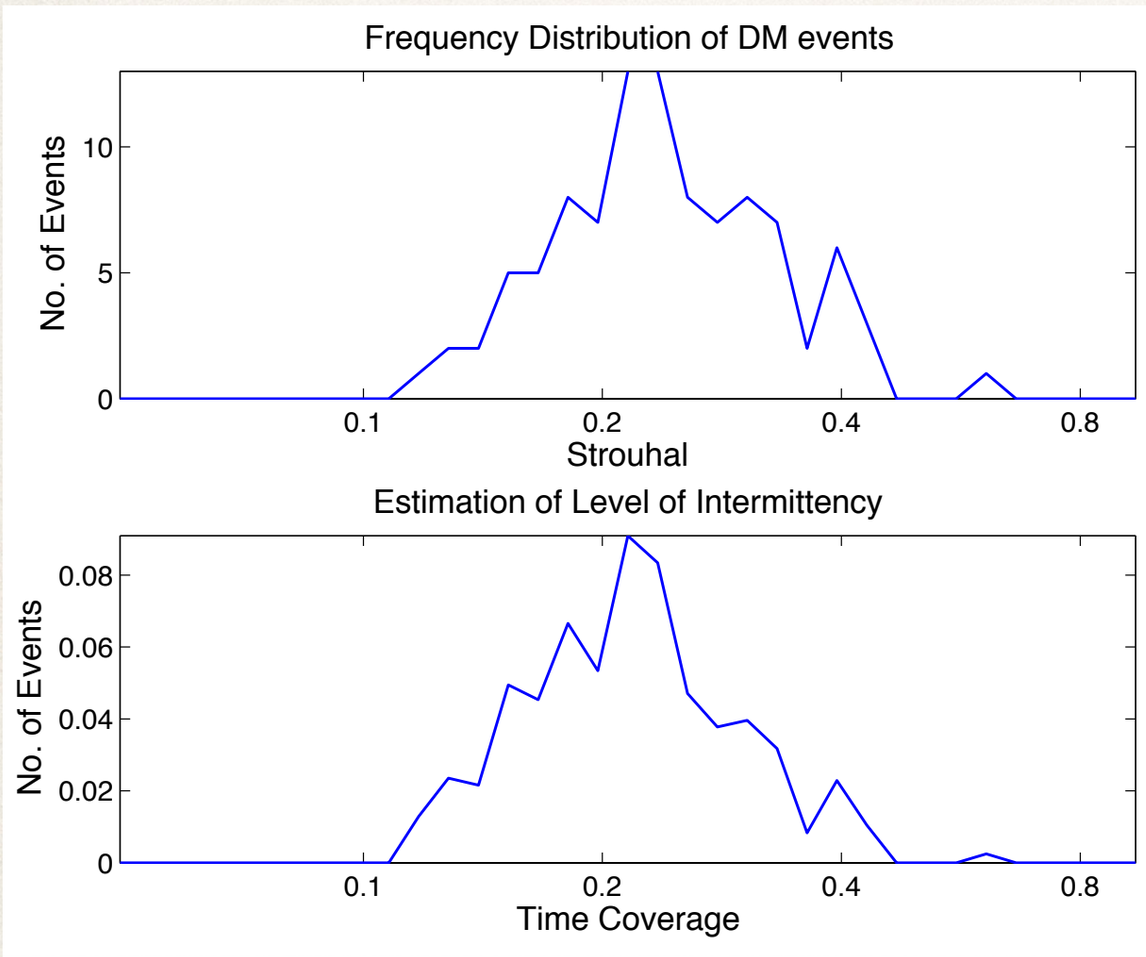
- 'Metric' of events: Energetic ('loud' in the FF); Main NF-FF correlation contributors;
Similar patterns in NF and FF signals



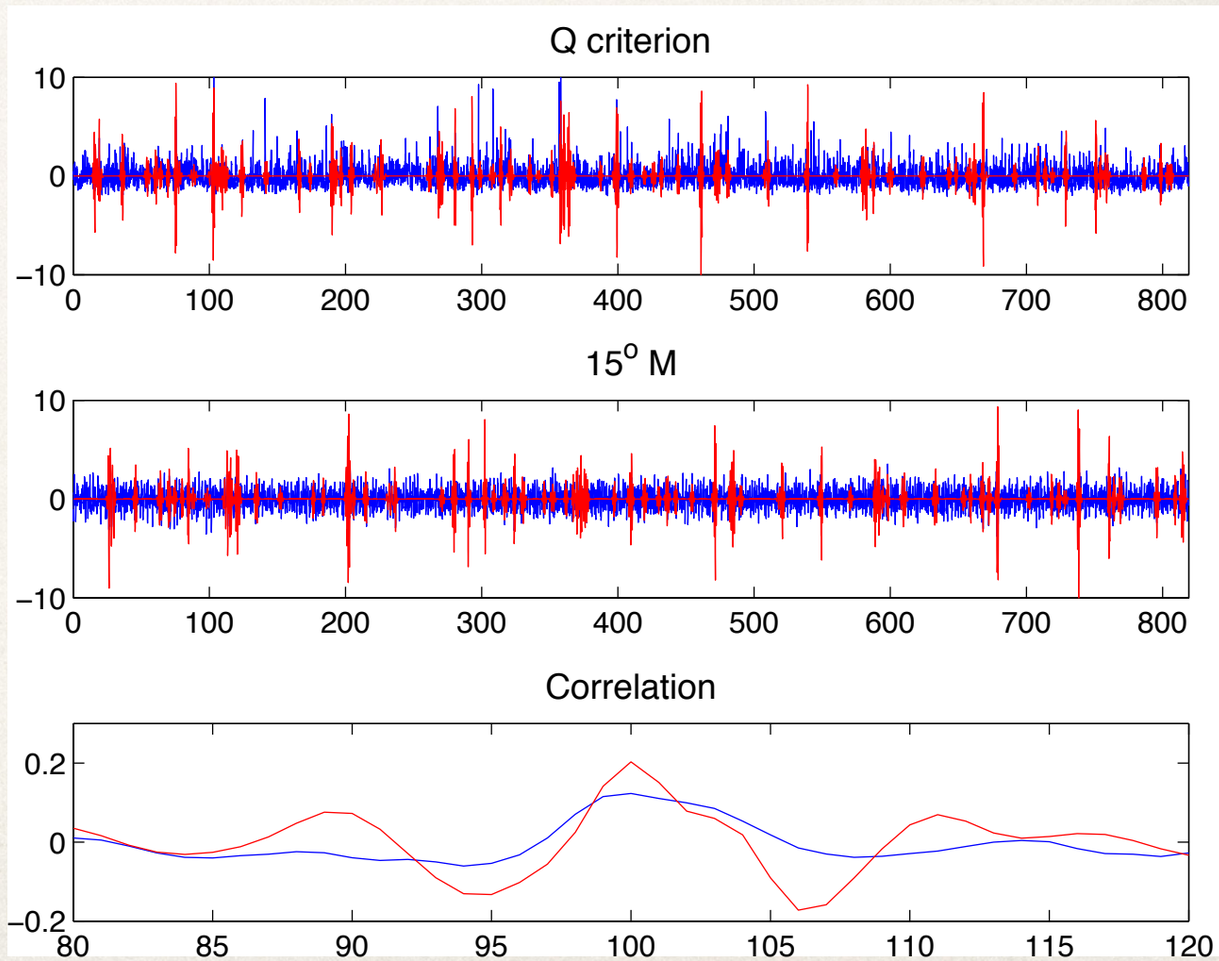
Analysis of the Events

— Statistics, (Inverse) Wavelet Transform

- Event property distribution:



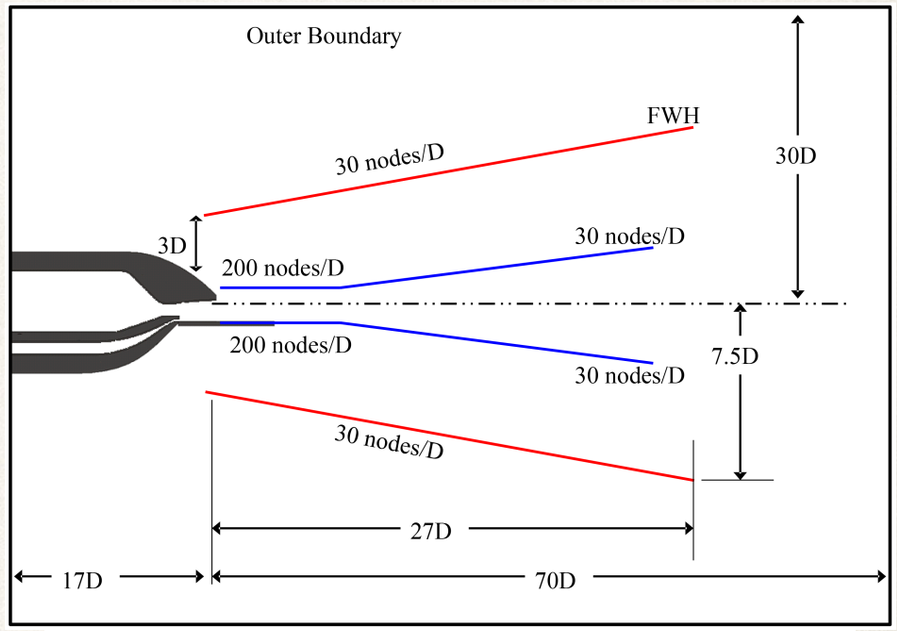
- Analysis of the filtered signal:

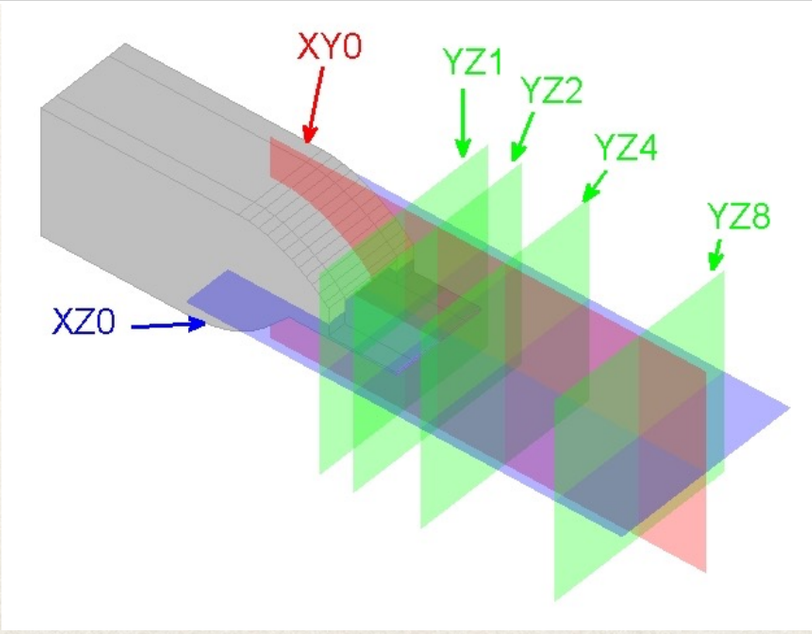


Supersonic 2-Stream Jet

LES Data

- Rectangular nozzle + wall jet
- 60 million tetrahedral cells (Ruscher et al. 2015, NRL's JENRE code)
- Core jet $Ma_1 = 1.6$, $NPR_1 = 4.25$;
  Wall jet $Ma_3 = 1.0$, $NPR_3 = 1.89$
- 8192 samples;
  sampling rate = 200kHz





Supersonic 2-Stream Jet

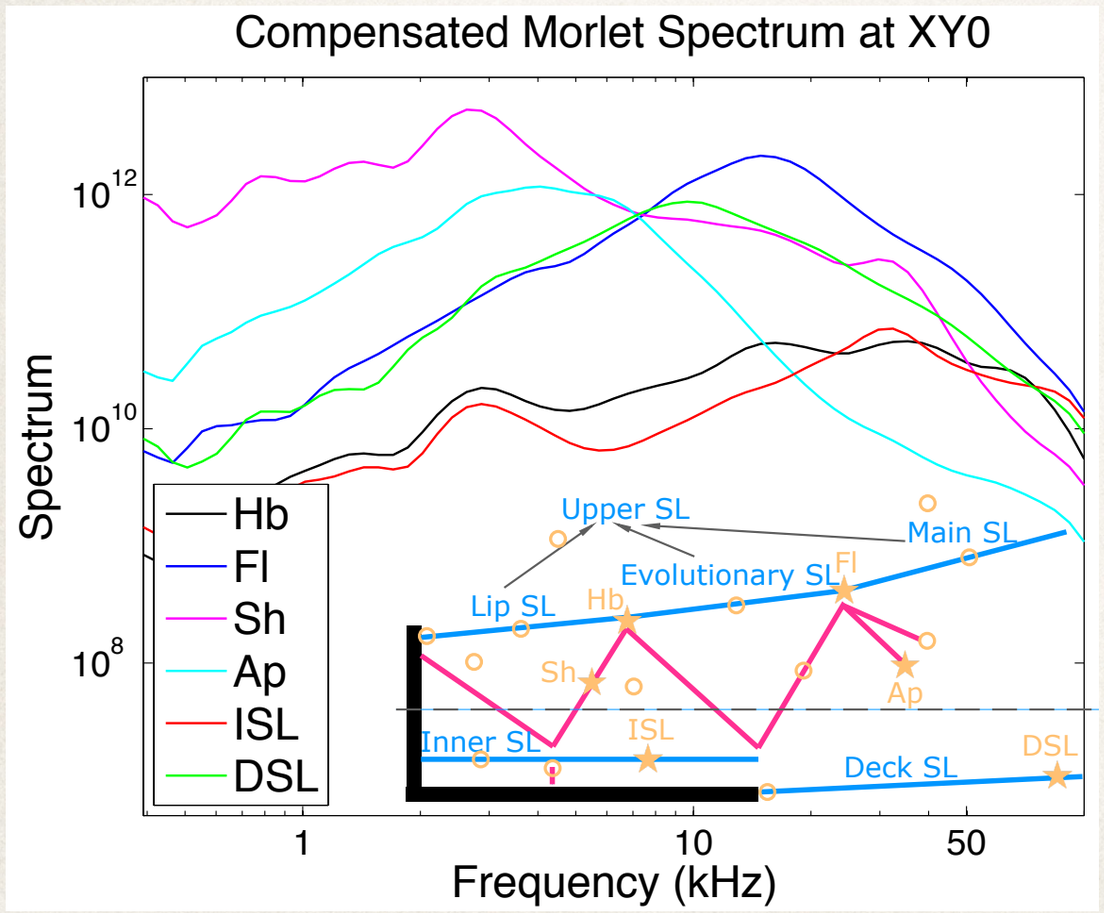
Description of the Prominent Flow Structures

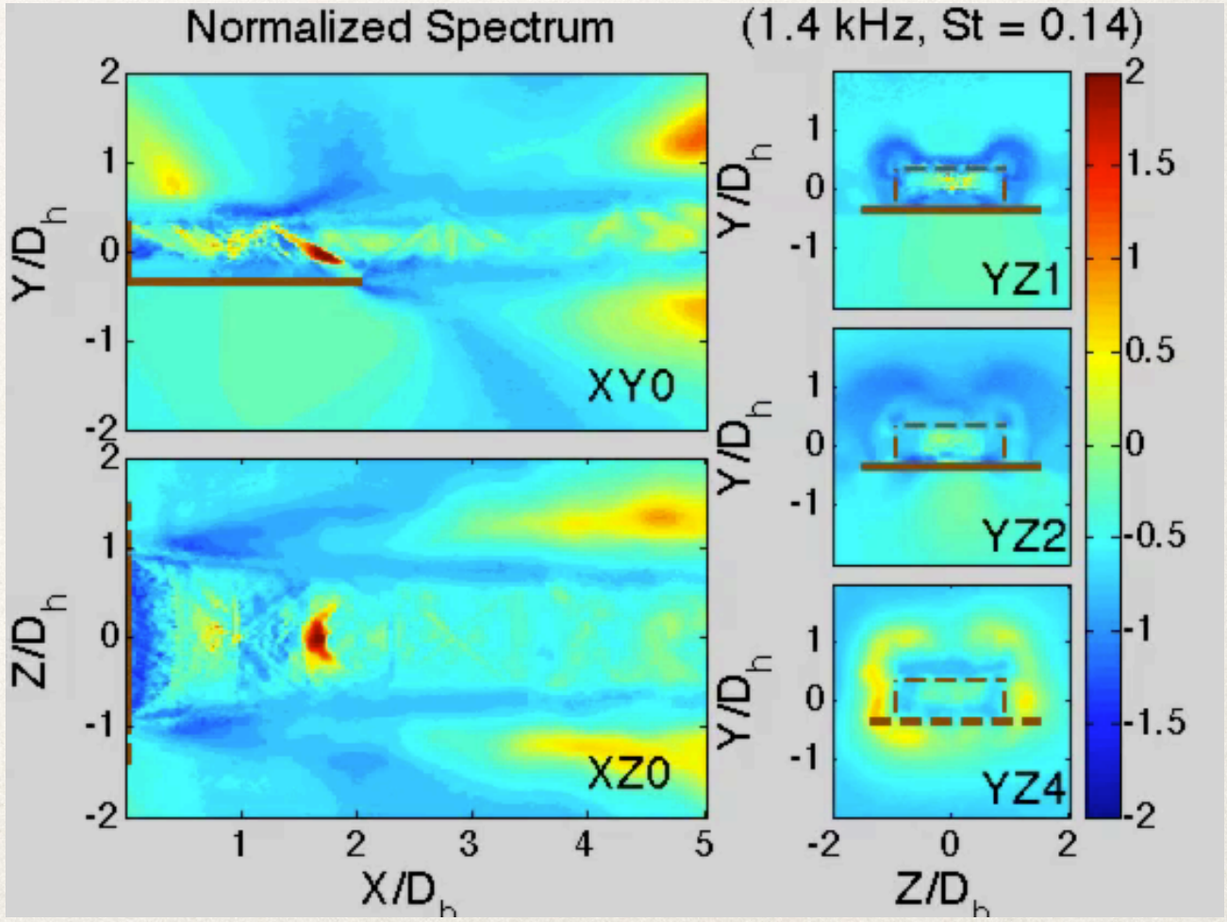
Spectral Analysis

— Morlet Compensated Spectrum

- Normalized spectrum:

$$\widetilde{E}_M(\omega, x_0, y_0) = \frac{E_M - \bar{E}_M}{std(E_M)} =< E_M(\omega, x_0, y_0) >$$





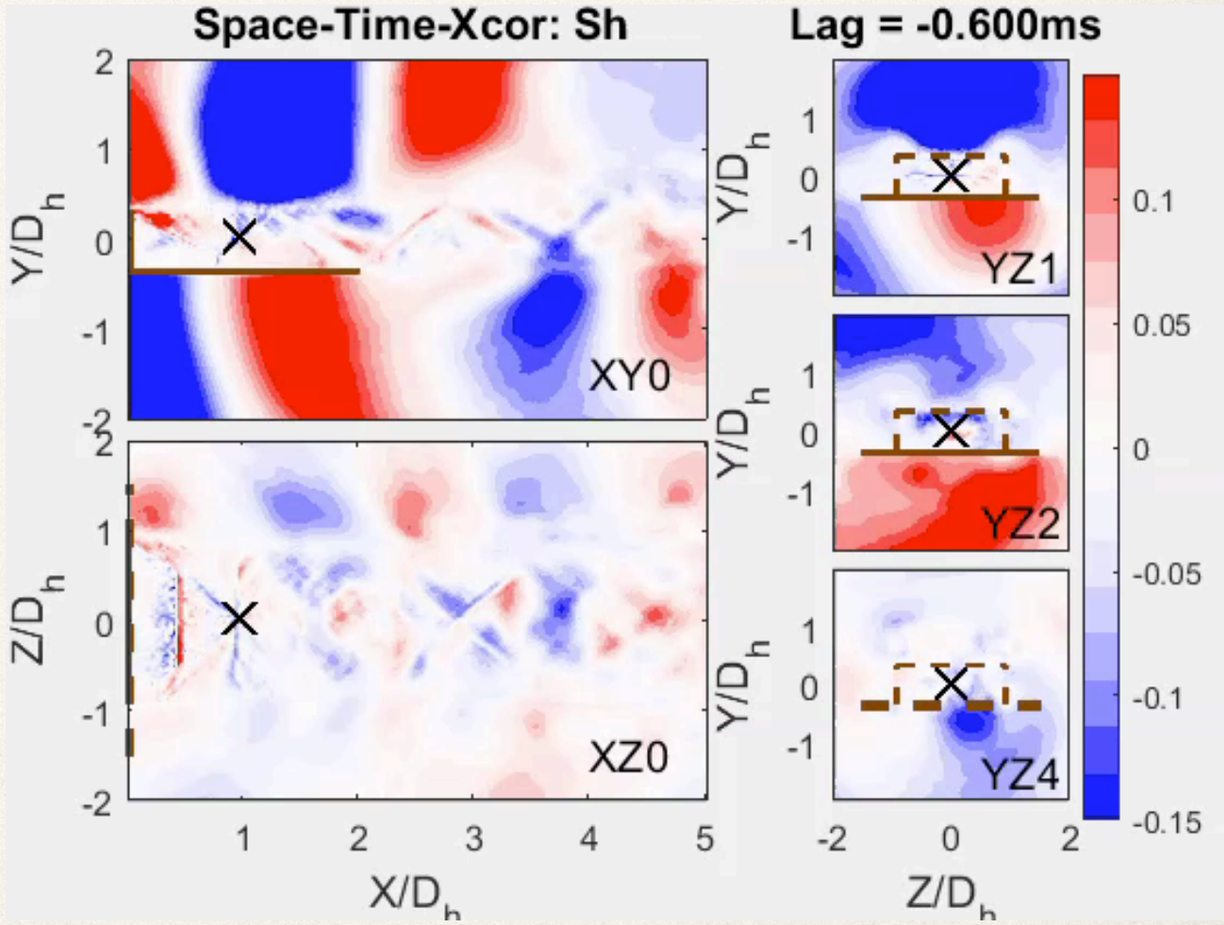
Evolution of Structures

— Space-Time Correlation

- With hot-spot Sh (Shock):

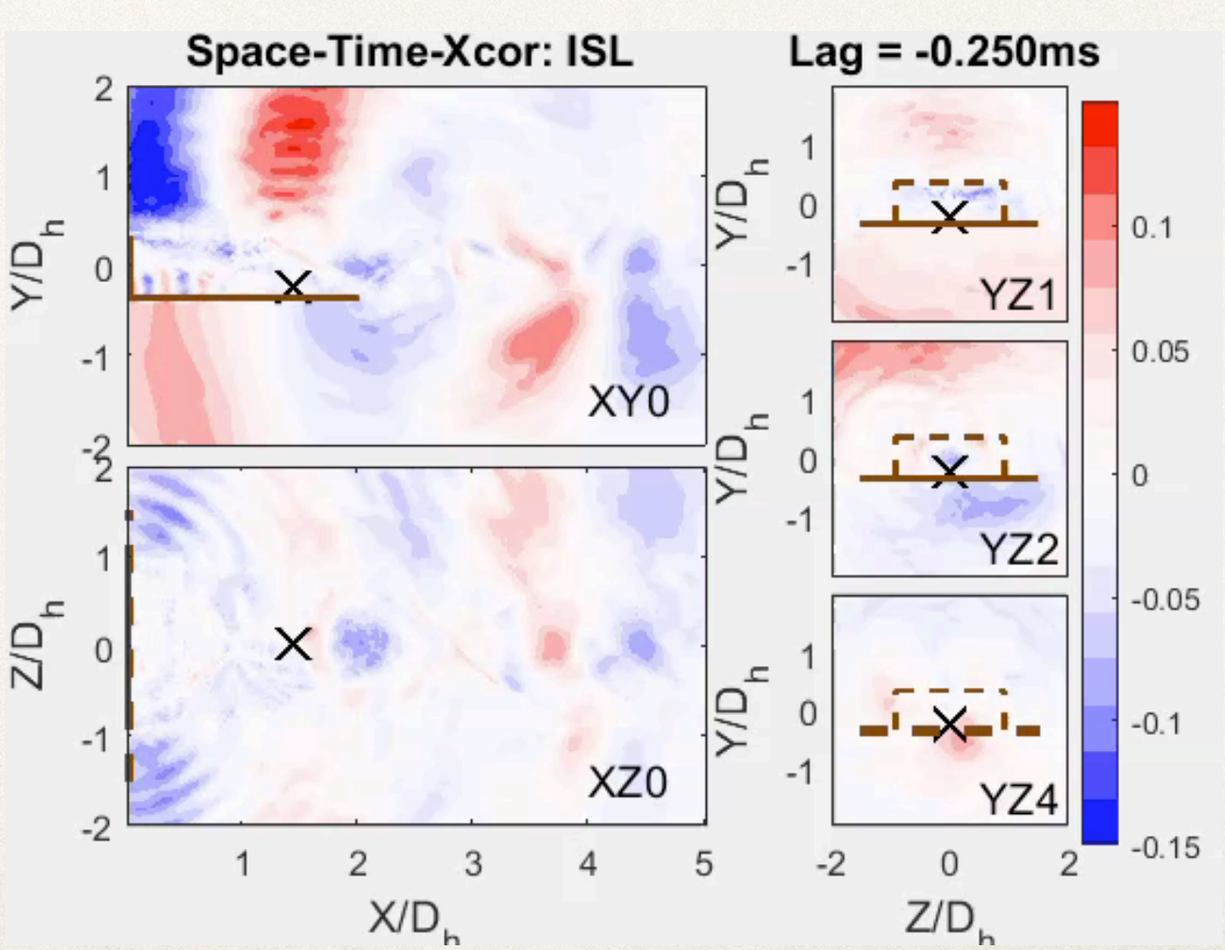
  - Very wide regions show periodicity (estimated as 0.39ms or 2.6kHz);

  - Upstream propagation outside jet stream;
  - Downstream propagation along shear layers and in shock cells



- With hot-spot ISL (Inner Shear Layer):

  - Localized pulsing propagating along Inner Shear Layer
  - Propagation along the sides of the shocks
  - Acoustic waves radiating from the shock-shear-layer intersections and the deck edge



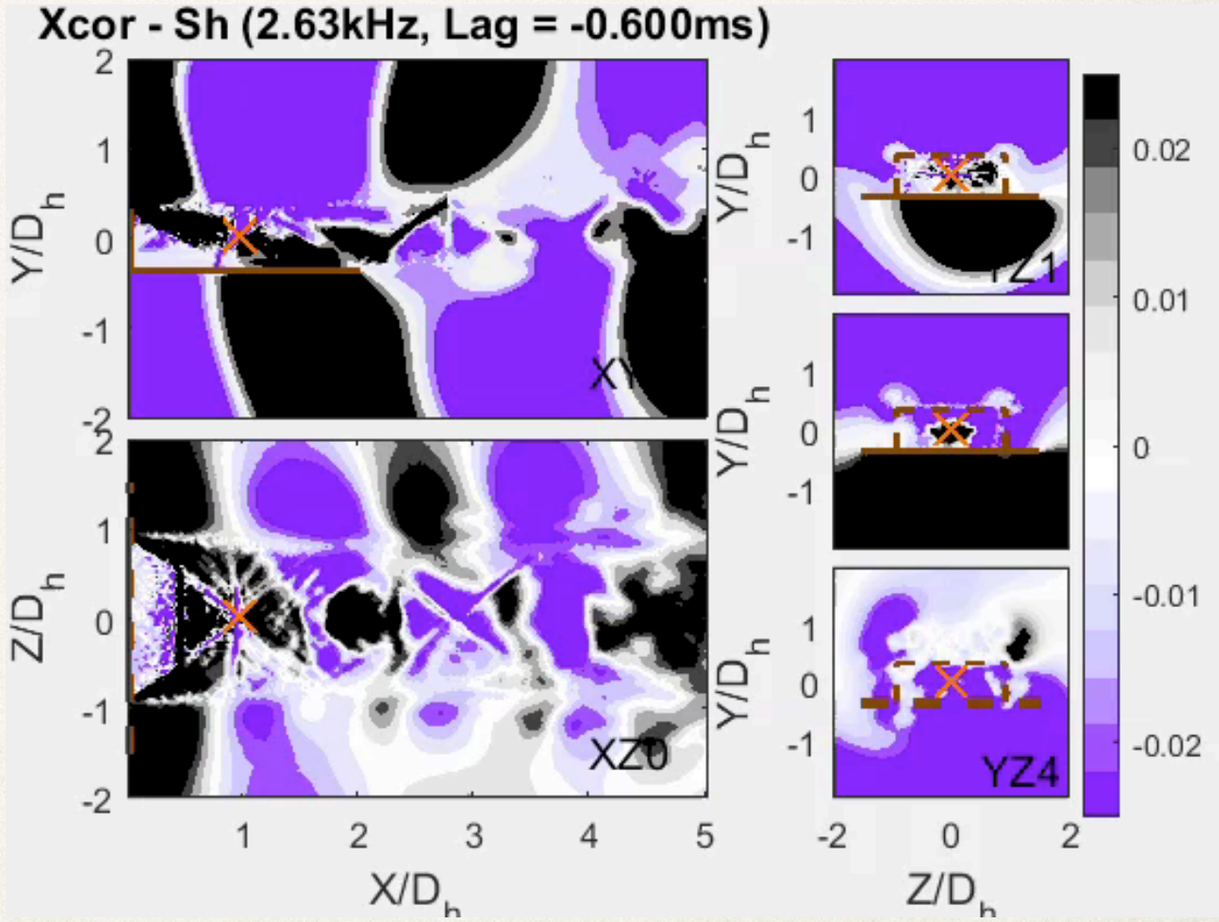
Frequency-Specific Features

— Continuous Wavelet, Correlation

- With hot-spot Sh:

  - Enhanced periodic patterns at 2.63kHz

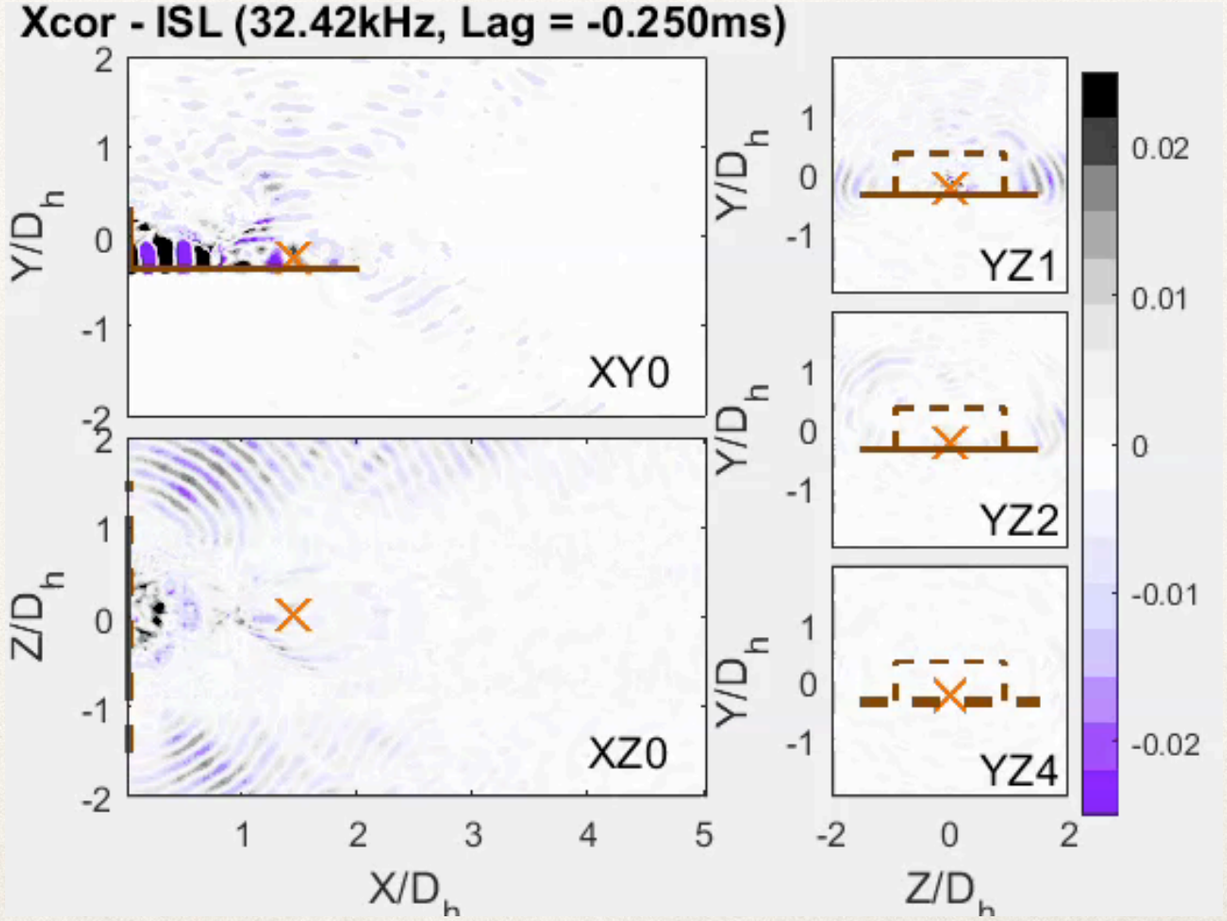
  - Non-dimensionalized to Strouhal 0.25 with nozzle diameter D_h and main stream speed $Ma_1 \cdot c_0$



- With hot-spot ISL:

  - At 32.4kHz, structures propagating along inner shear layers and in the lower shock cells, acoustic wave radiations;

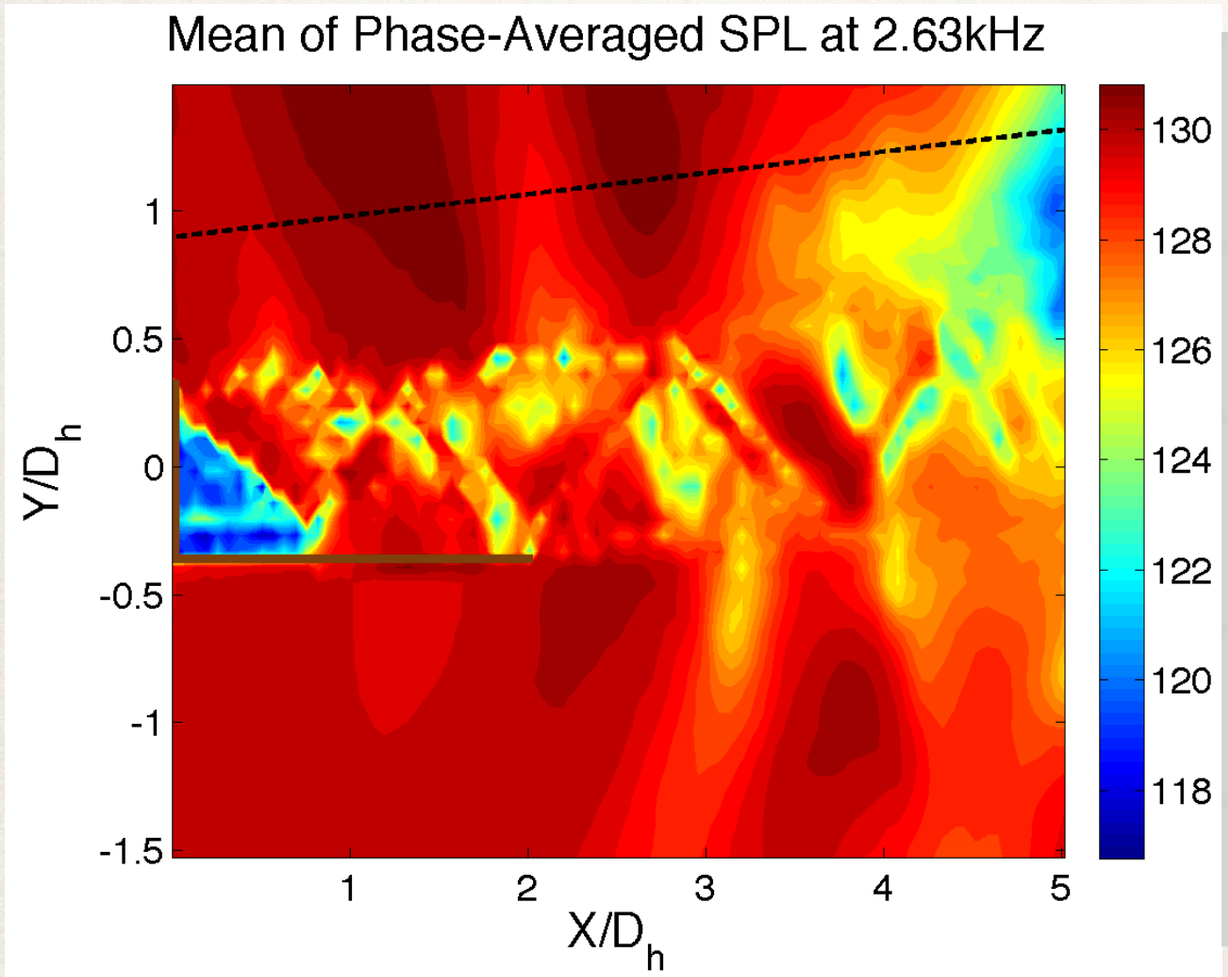
  - Non-dimensionalized to Strouhal = 0.26 using the splitter plate thickness and the average velocity

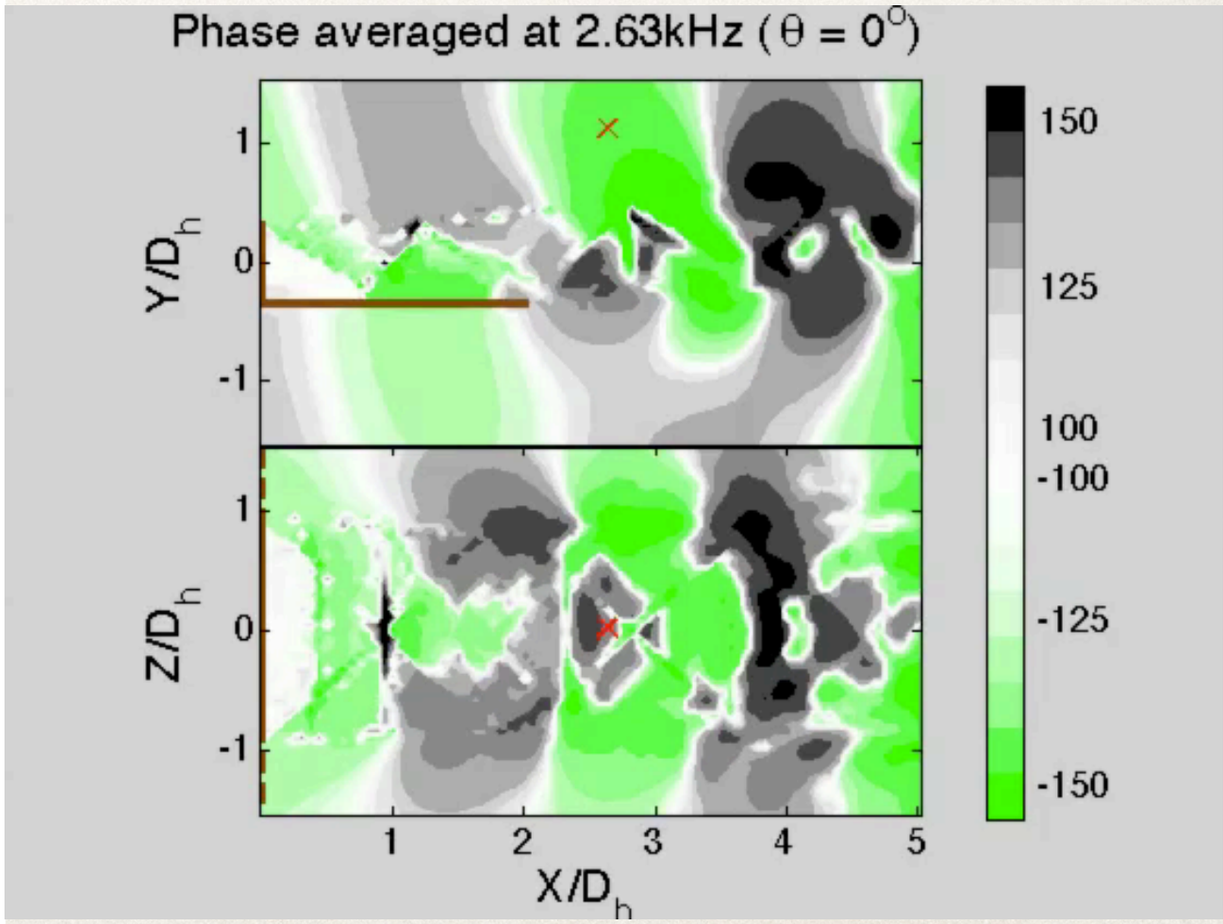


Structures with Periodicity

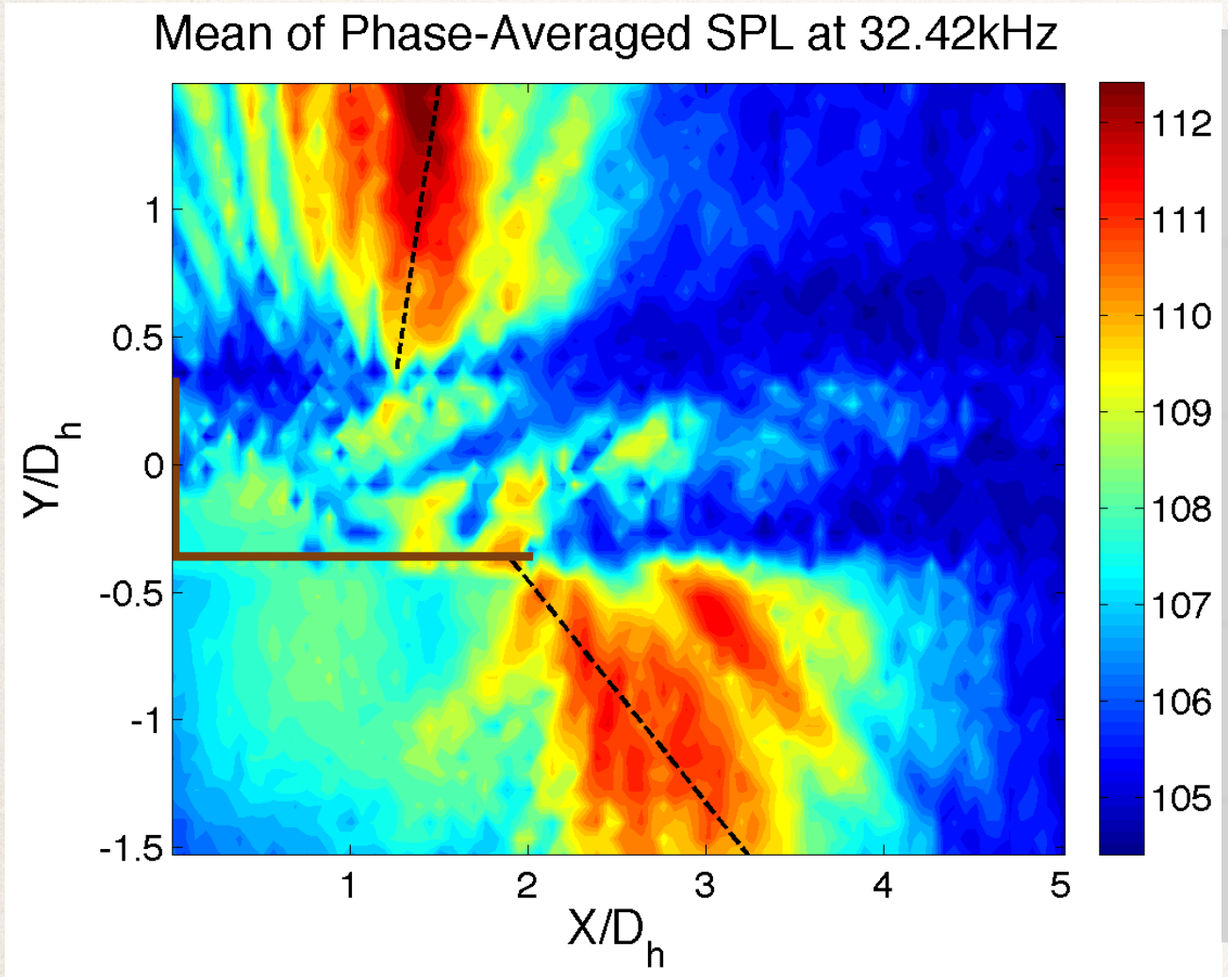
— Continuous Wavelet, Phase-Averaging

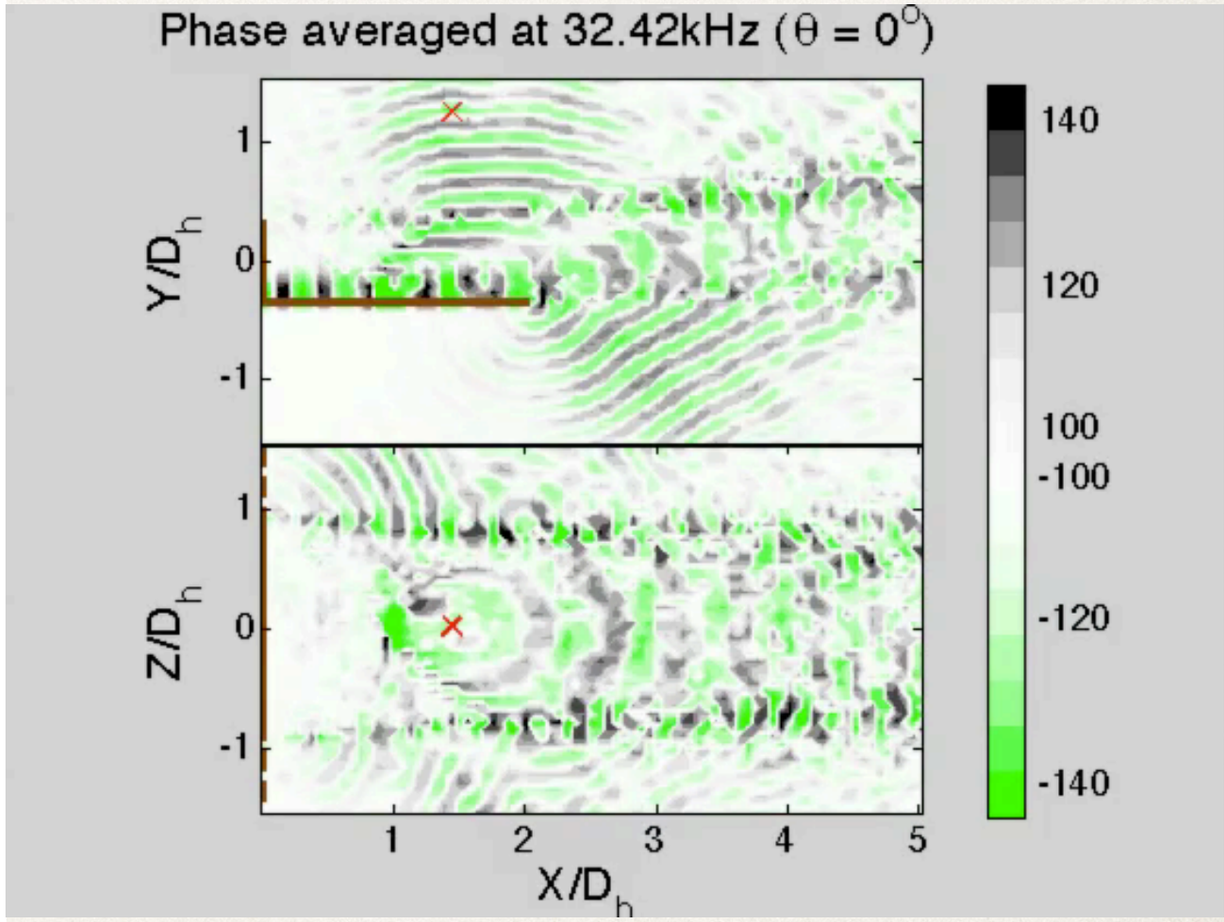
- Signals filtered at 2.63kHz, then phase-averaged:





- Signals filtered at 32.4kHz, then phase-averaged:





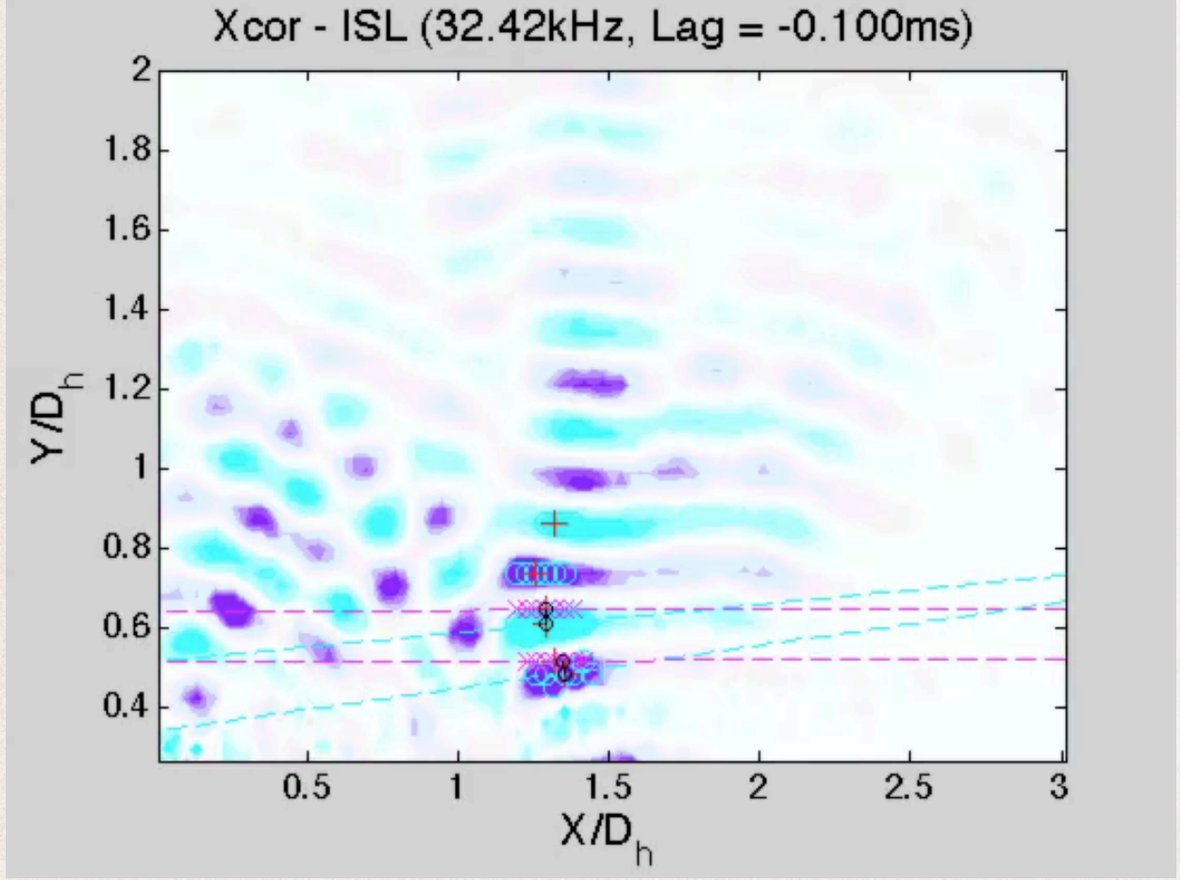
Supersonic 2-Stream Jet

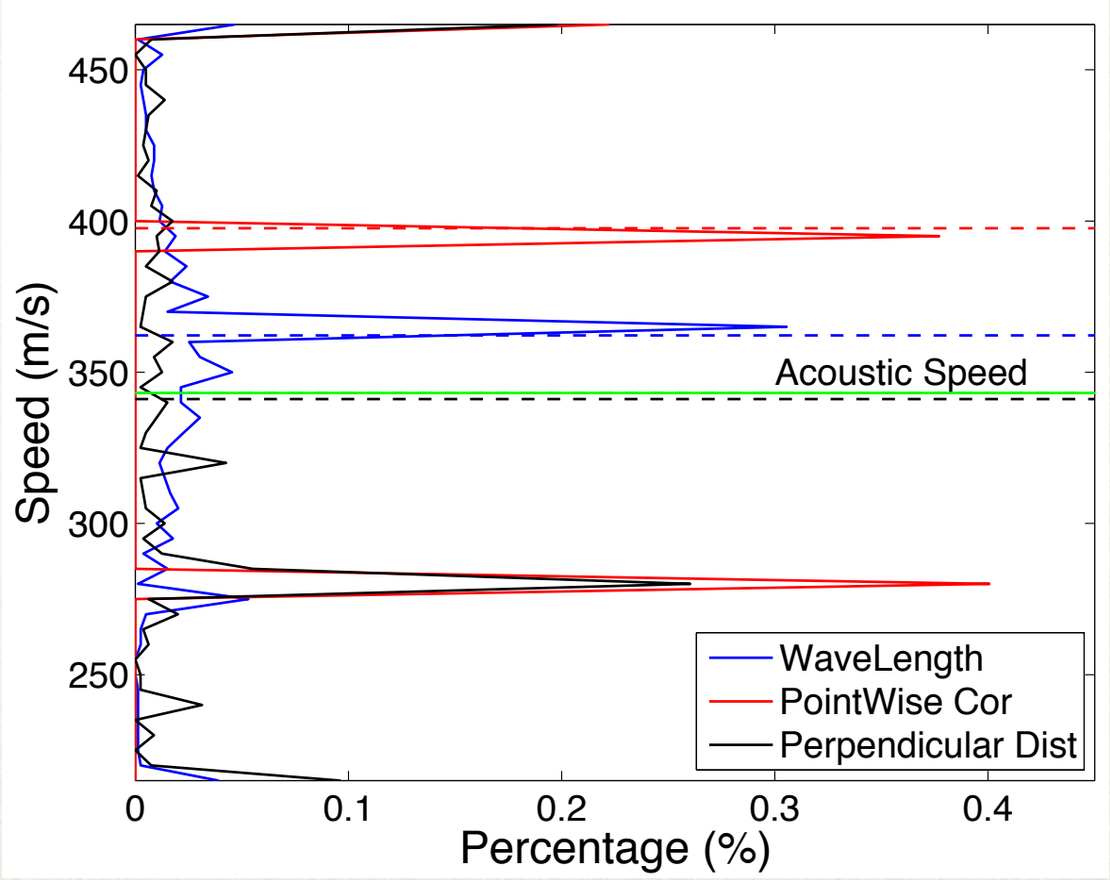
Events Related to Noise Production

Acoustic Propagation Speed and Path

— Correlation, Continuous Wavelet, Pattern Recognition

- Stroboscopic effect —> actual propagation path?
- Propagation speed —> perpendicular acoustic path

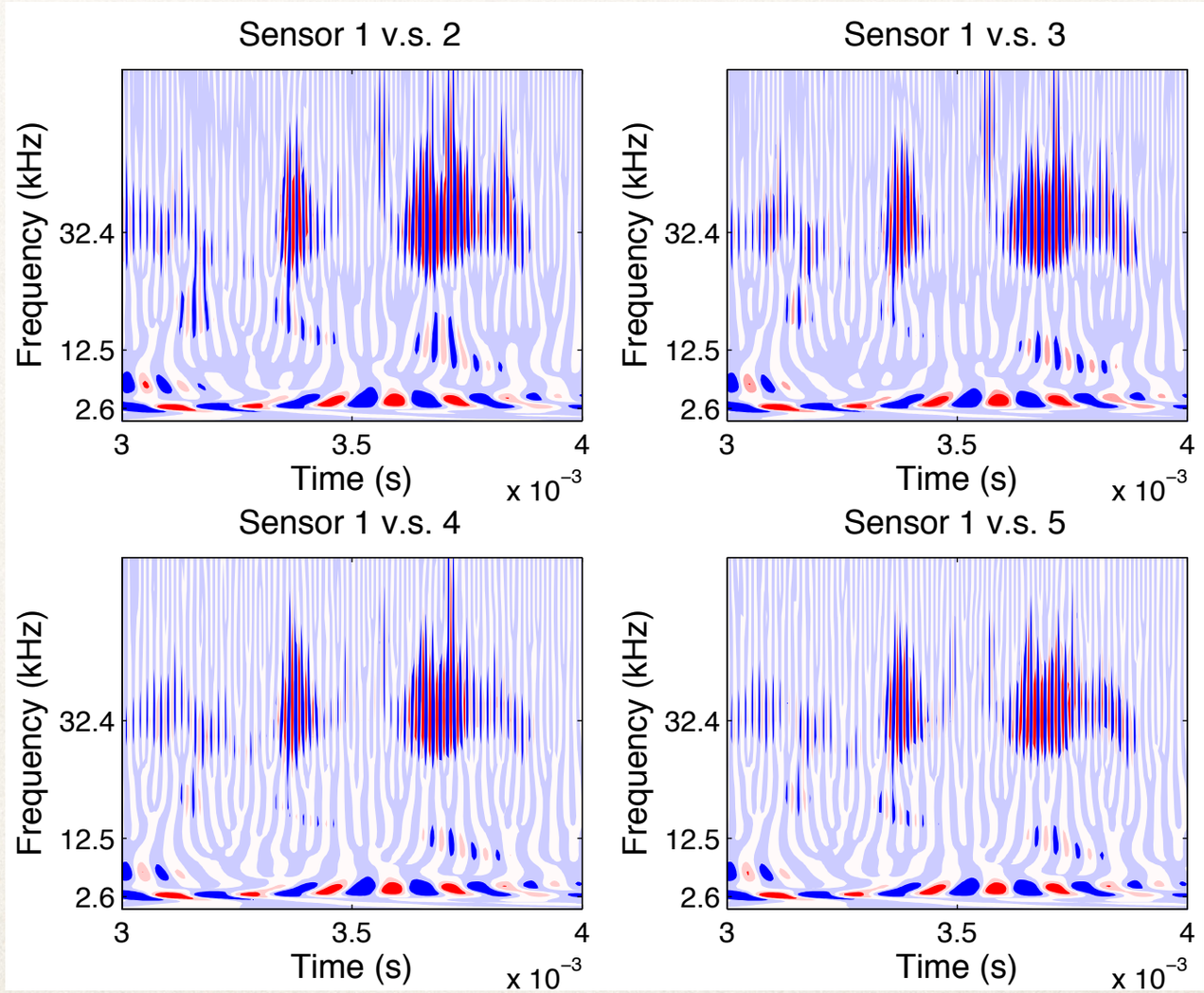




Event Extraction (In Progress)

— Correlation, Continuous Wavelet, Pattern Recognition

- Tracking events propagating through sensors



Conclusions

- Propagation paths
  - Whole field space-time cross-correlation
  - Frequency-specific cross-correlations
  - TFL: propagation events
- Phase averaging, if there is a pulse
- Modulation
- Promising for SWBLI